being cooled while another lens is being heated prior to cooling. A plurality of lenses can be simultaneously heated, if desired.

Fig. 5 shows a lens 35 supported between two iron rods 36 and 37. The rods 36 and 37 taper into rounded points 38 and 39 respectively. The points 38 and 39 each have a diameter of approximately 1 mm. and contact asbestos pads 40 and 41, respectively. The pads are circular and have a diameter of about ¼". Because iron has a relatively high coefficient of heat conductivity relative to carbon or graphite, it was found necessary to employ the asbestos pads to decrease the rate of heat transfer through the iron points to decrease breakage due to a too rapid heat dissipation. The heated lens usually cracks when a cold metal point of high heat conductivity and area is brought into contact therewith. Due to the cushioning effect of the asbestos pads, the pressure for supporting the heated lens may be increased somewhat, over than referred to in describing Fig. 4. For example, a pound to a pound and one-half weight can be exerted in a vertical direction on rod 36 without piercing the asbestos pads 40 and 41 or the lens 35.

Fig. 6 shows a heated lens 42 supported on a lens stand 43 of refractory material or other material having a low coefficient of heat conductivity and disposed between hollow metal tubes 44 and 45. The tubes 44 and 45 may be composed of any metal, such as copper, nickel, iron, etc. or any of the well-known alloys. The tubes 44 and 45 are provided with reduced circular orifices 46 and 47, each having a diameter of approximately 1 mm. The orifices 46 and 47 are preferably, but not necessarily, so spaced from the lens 42 that both the metal and the air blown through the orifices jointly contribute to the rapid cooling step. The distance separating each orifice from the heated lens will depend upon the coefficient of heat conductivity of the metal comprising the tubes.

When employing air in the toughening of spectacle lenses it is preferred to have the air under pressure, say two or three atmospheres, in order to assure a rapid cooling of the lenses to form strain patterns therein. An air filter and air cooler are preferably employed to eliminate any foreign particles from the air striking the heated lens and to better establish a rapid heat transfer relationship to form the strain pattern therein. Any suitable apparatus known to the art of toughening glass generally may be employed to blow air against the heated lens through the hollow tubes 44 and 45 and, inasmuch as this apparatus does not of itself form a part of this invention, it has not been shown or described in detail.

Fig. 7 illustrates a modified method of rapidly cooling one face of the lens 48 through the medium of a solid metal rod 49 which tapers into a reduced portion 50 which is spaced from the lens 48. The distance separating the portion 50 and the lens 48 depends upon the particular metal and the shape and size of the rod 49. Generally, a rod made of copper will have to be spaced further from the lens in order not to crack said lens than an iron rod, all other things being equal, because copper is a more rapid conductor than iron. If the rod is iron and the portion 50 has a diameter of about 1 mm., the space between the heated lens and the portion 50 may be approximately 2 mm.

Fig. 2 illustrates a heated lens 51 centrally supported between oppositely disposed carbon tips 52 and 53. A plurality of apertures are spaced around each carbon tip, as at 54 and 55, and communicate with hollow tubes 56 and 57, respectively. The tip 52 threadedly engages in the lower end of tube 56 while the tip 53 threadedly engages in the lower end portion of tube 57. The apertures 54 and 55 are disposed at an angle so that air blown through the tubes is directed against the heated lens 51 to assist in the rapid cooling thereof.

The composition of the rods employed in conducting heat away from the heated lens can vary. Ordinarily such metals as iron, copper or other metals of high heat conductivity are unsuitable in the preferred method of applying pressure to the heated lens so that it is supported during the cooling period, unless some insulating material as asbestos is employed to insulate the cold metal from the hot lens. This results from the fact that the area of lens contact has to be so small when employing metals so that the lens will not crack that it is difficult to apply supporting pressure on the metal rods without bending the points out of shape or denting the lens supported therebetween. Usually the heated lens will crack when cold metals having a high coefficient of heat conductivity contact the heated lens where the circular area of contact has a diameter of 1 mm. or more. For example, those metals having the same or a higher conductivity than iron.

Carbon and graphite are suitable as solid conducting materials in the preferred practice of applying supporting pressure to a heated lens for their coefficients of conductivity are of such magnitude relative to the coefficient of conductivity of air that a too rapid dissi-

pation of heat does not occur at the point or points that the carbon or graphite rod contacts the heated lens while it cools so as to crack the lens. Other solid conducting materials are suitable provided their coefficients of conductivity are not so high that heat is conducted away from the lens at so rapid a rate that the lens cracks.

A person skilled in the art can ascertain suitable conducting solid materials by reviewing the conductivities of the materials and comparing these conductivities with the conductivity of air having in mind that metals, such as copper, iron and steel are generally unsuitable for direct contact with a heated lens where the areas of lens contact has a diameter of approximately 1 mm. or more and that materials, such as carbon and graphite have suitable coefficients of conductivity for direct contact, other factors being equal.

Solid materials having lower coefficients of conductivity than carbon and graphite are suitable to conduct heat away from the heated lens provided the ratio of the heat conductivity of the solid material to the heat conductivity of air is such that heat is conducted away from the heated lens through the medium of the solid material at a fast enough rate compared to the rate at which the remaining portion of the heated lens loses its heat to the surrounding air so that a normally invisible strain pattern is formed in the lens or the lens is toughened. The shape of the strain pattern depends upon the relationship of the area of contact of the solid conducting material with the heated lens relative to the remaining portion of the lens which loses its heat to the air surrounding the lens as it cools naturally.

Solid materials having higher coefficients of conductivity than carbon or graphite and yet lower than metals like iron may be used for direct contact with the heated lens provided their coefficients of heat conductivity are not so high relative to the conductivity of air that the lens cracks.

Generally any solid material which has a coefficient of heat conductivity greater than that of air is suitable in the practice of this invention provided a relationship of heat transfer can be established relative to the heated lens so that the heat is conducted away at different rates from the heated lens in such manner that a normally invisible strain pattern is formed in the lens. If the solid material has a coefficient of heat conductivity which is too great compared with air, an insulating material, such as asbestos, can be employed to decrease the rate at which the heat is dissipated so as not to crack the lens It is preferred to exert pressure at a point on the asbestos pad which contacts the heated lens to insure a more rapid heat dissipation at this point and to insure a well defined strain pattern, as well as supporting the lens while it cools naturally.

In the heat treatment of the optical lens prior to the rapid cooling step, any suitable temperature controlled oven may be employed. It is preferred to employ an oven with exposed coils in the two side walls thereof. Depending upon the particular type of oven employed, position of pyrometer, etc., the time and temperatures of the graph of Fig. 1 may vary somewhat.

A lens stand generally indicated as 66 may be used for supporting the lens during heating in an oven, and comprises a split iron ring portion 67 provided with three equally spaced apart supporting legs 68, each of which legs is provided with a portion 69 which overlaps the ring 67. The portions 69 project downwardly toward a common point but do not meet, providing a resting place for the lens 70. The lens stand 66 can be made of any suitable material, e.g., refractory material.

The following examples will illustrate various ways of carrying out the invention:—

Example I.

A spectacle lens, corrected for vision and made of ordinary spectacle crown glass, is uniformly heated in a temperature controlled oven for three minutes at a temperature of 1150° F. After the heating period the heated lens is carefully removed from the oven and substantially centrally supported between two oppositely disposed pointed carbon or graphite rods, having a rounded pointed portion of 1 mm. diameter and allowed to cool naturally in its supported position. When the lens is viewed through a polariscope a cross-shaped strain pattern is visible. (See Fig. 2.) It is preferred to dispose the heated lens between two conducting points but, if desired, one face of the lens may be cooled more rapidly than the other face through the medium of one conducting point.

Example II.

A second spectacle lens similar to the lens of Example I is treated like the lens of Example I. When the second lens is viewed through a polariscope, the cross-shaped strain pattern is visible, which is the same as the cross-shaped strain pattern appearing in the lens of Example I.

PATENT SPECIFICATION

Application Date: May 5, 1943. No. 7095/43.

563,800

Complete Specification Accepted: Aug. 30, 1944.

COMPLETE SPECIFICATION

Improved Manufacture of Toughened Glass Lenses and like Glass Objects

I, ARTHUR WILLIAM PARFITT, a British subject, of Stafford House, Norfolk Street, London, W.C.2, do hereby declare the nature of this invention (a communication from Temp-R-Lens Corporation, a corporation organised and existing under the laws of the State of Indiana, of Lake Theatre Building, Michigan City, State of Indiana, United States of America,) and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The present invention generally relates to the manufacture of ophthalmic lenses, such as spectacle lenses and like glass objects, toughened or tempered by heating to approximately the softening point of the glass and subsequent rapid cooling.

The invention contemplates the toughening of ophthalmic lenses and other glass articles of any color, kind, size, shape, power or thickness, including bifocal, multifocal or single vision lenses, to render them more resistant to breakage.

The primary object of the invention is to provide a simple method of and apparatus for toughening glass articles, especially spectacle lenses which preferably have been already ground to provide the necessary curves for the correction of vision, without affecting the optical properties of the lenses or the corrective power factor or without sagging or warping the lenses beyond allowable tolerances.

In the tempering of massive glass articles such as sheets of plate glass, it has been proposed to effect the rapid cooling by placing the sheet in vertical position between hollow panels through which cooling medium circulates said panels being provided with bosses or projections, symmetrically spaced, which contact both faces of the sheet. It has also been proposed to effect the cooling of such sheets by means of series of air jets disposed in a symmetrical pattern. The tempering of small thin objects such as opthalmic lenses presents problems very different from that of cooling massive articles, since the amount of stored heat is much smaller and the cooling is more rapid and difficult of control. Also the preservation of the accuracy of the surfaces is relatively more important in a glass lens, in view of which prior methods of temper cooling glass lenses have proposed to keep the curved surface of the lens in contact over the whole or most of its area with a correspondingly shaped conductor of heat.

The present invention provides a method of and apparatus for the temper cooling of lenses and like glass objects which will form a desired strain pattern in the object.

The invention consists in a method for toughening a lens or like article of glass by heating the article to near softening point and rapidly cooling it, characterized by effecting said cooling through the medium of a solid conductor or a jet of gaseous cooling medium applied at the centre point of symmetry of a desired strain pattern in the glass. In performing this method the heated lens is preferably supported between solid conducting points which properly rapidly cool the lens as well as support said lens while cooling.

The invention also consists in providing a toughened ophthalmic lens, such as a spectacle lens, corrected for vision, e.g., a spectacle lens for rimmed glasses and a drilled lens for rimless glasses, or a similar glass article such as a crystal or cover glass for a watch or instrument, characterized by a symmetrical strain pattern produced by the aforesaid method, preferably in the form of a cross.

The invention further consists in providing apparatus for cooling a heated lens or like glass object in tempering characterized by a pointed conductor of heat, or a fine jet for delivery of gaseous cooling medium under pressure, applicable to the centre point of symmetry of the desired strain pattern in the lens while it is supported in air.

The invention also includes a method of toughening spectacle lenses, preferably corrected for vision before toughening, e.g., lenses for rimmed glasses and

[Price 1/-]

drilled lenses for rimless glasses, employing air alone in a fine jet as the rapid cooling medium.

The important feature of the method and apparatus is the application of an intense cooling restricted to substantially a point area at the centre of symmetry of the desired strain pattern.

Referring to the accompanying drawings, wherein like numerals refer to like or corresponding parts throughout the several views,

Figure 1 illustrates a graph showing appropriate times and temperatures at which a lens may be heated before the rapid cooling step;

Fig. 2 shows a toughened lens with a cross-shaped strain pattern visible only when it is viewed through a polariscope;

Fig. 3 shows a cross-shaped strain pattern which results from employing two jets of air as the cooling medium in the lens toughening method:

Fig. 4 shows a side elevation of the equipment for rapidly cooling a plurality of heated lenses;

Fig. 5 shows a detail of a modfied form of the invention and illustrates another means for supporting and rapidly cooling a heated lens;

Fig. 6 shows a detail of a modified form of the invention wherein the heated lens is disposed between two cooling jets of air;

Fig. 7 shows a detail of another modified form of the invention wherein only one solid pointed conductor is disposed in rapid heat transfer relationship with a heated lens but does not touch said heated lens.

Fig. 8 shows a detail of a still further modification of the invention wherein the heated lens is supported between two carbon points and cooling air is also blown on the heated lens; and

Fig. 9 shows a drilled lens disposed on a lens stand, ready for insertion into an oven;

Referring now to the drawings and more particularly to Fig. 4. the numeral 20 generally indicates an apparatus for conducting heat away from a heated lens or the like, and simultaneously supporting the lens. The apparatus 20 comprises a base plate 21 of metal, plastic, wood or the like, which carries an upright member 22 in any suitable manner. The upright 22 is shown as threadedly engaging in the plate 21 but it may be otherwise secured thereto. The upright member 22 is provided with spaced ears 23 at the upper end portion thereof to receive the ears 24 of the arm 25. Pivot pin 26 secures the ears 23 and 24 together and permits pivotal movement of the arm 25 in a vertical direction about the pivot pin 26. The arm 25, which is adapted for pivotal movement, carries a carbon rod 27 which depends from the outer end portion thereof and is suitably secured thereto as by threaded engagement. The rod 27 tapers at the lower end portion into a rounded point 28 having a diameter of approximately 1 mm.

A second carbon rod 29 is secured to the base 21 as by threaded engagement. The rod 29 is vertically mounted and its upper end portion tapers into a rounded point 30 having a diameter of approximately 1 mm. The rods 27 and 29 are in substantial co-axial alignment and a heated lens 31 may be supported between the points 28 and 30 which rapidly conduct heat away from the lens to form a normally invisible strain pattern therein.

The conducting points 28 and 30 do not abut each other in the absence of the heated lens. see Fig. 7. A detent rod 32 is suitably secured to the plate 21 as by threaded engagement. The rod 32 extends vertically and the upper end thereof engages the underpart of arm 25 to stop the downward movement thereof at a predetermined point. The rod 32 may be adjusted vertically and it is preferred that a space of 0.5 mm. exist between points 28 and 30 in the absence of lens 31.

Any suitable detent means may be employed to regulate the distance between points 28 and 30. For example, the upright 22 may be constructed at the pivot portion to inhibit downward movement of arm 25 below a predetermined level or the detent rod 32 may be secured to arm 25 and have its lower end engage the base 21. The invention includes all means for limiting the movement of rod 27 relative to rod 29 so that the points 28 and 30 will not abut when a heated lens is not being supported therebetween.

A spring 33 is secured to the arm 25 and upright 22, as by hooks 34. The spring 33 urges the carbon rod 27 toward the carbon rod 29 to support the lens between points 28 and 30. It is only necessary to have sufficient pressure on the arm 25 to support the lens between points 28 and 30. If the lens 31 is disposed substantially centrally between the points 28 and 30, the pressure required is very small. If desired. the spring 33 can be eliminated by properly adjusting the weight of arm 25 so that sufficient pressure is brought upon the heated lens 31 to hold it in position while it cools.

If desired, three pairs of cooling assemblies can be employed to provide a more or less continuous lens toughening method, wherein one or two lenses are

EXAMPLE III.

A drilled ophthalmic lens approximately 2 mm. thick at its thinnest point, made of spectacle crown glass and corrected for vision, is heated in a temperature controlled oven for five minutes at a temperature of 1125° F. After the heating period the heated lens is carefully removed from the oven and heat is rapidly conducted away from one or more points on the surface of the heated lens through the medium of one or more pointed pencil-shaped carbon rods having a rounded pointed portion of 1 mm. diameter which contacts the heated lens. The remaining portion of the lens is preferably allowed to cool naturally.

EXAMPLE IV.

The lens of Example III is heated for substantially a temperature and time indicated by the graph of Fig. 1, preferably within the 1100°—1200° F. range, and rapidly cooled like the lens of Example III.

EXAMPLE V.

A spectacle lens, corrected for vision and made of ordinary spectacle crown glass, is uniformly heated in a temperature controlled oven for three minutes at a temperature of 1150° F. After the heating period the heated lens is carefully removed from the oven and substantially centrally supported between two oppositely disposed carbon or graphite rods having a rounded pointed portion of 1 mm. diameter. A gas, such as air, is directed against the heated lens. The lens is cooled rapidly through the medium of both the carbon rods and the gas, such as air.

EXAMPLE VI.

The lens treatment of Example IV, wherein the rapid cooling step is accomplished through the medium of any solid conductor, either alone or in combination with air.

EXAMPLE VII.

A drilled spectacle lens, corrected for vision, of conventional shape and made of spectacle crown glass and suitable for rimless glasses, having a thickness of approximately 0.2 mm. at its thinnest point, is uniformly heated between 1140° F.—1155° F. for a period of 2.5—3 minutes in a temperature controlled oven to somewhat soften the surfaces thereof and without warping or sagging the lens. Said heated lens is then removed from the oven and heat rapidly conducted away from the center of the lens through the medium of two oppositely disposed graphite rods having a rounded pointed lens contacting surface of 1 mm. A normally invisible cross-shaped strain pattern will be visible when the lens is viewed through a polariscope.

EXAMPLE VIII.

A spectacle lens, such as one employed for rimmed glasses or a drilled lens as employed for rimless glasses, is uniformly heated in a temperature controlled oven for three minutes at a temperature of 1150° F. After the heating period the heated lens is carefully removed and quickly disposed between two jets having an orifice diameter of approximately 1 mm., and air, under two or three atmospheres pressure, is directed against the center of the heated lens to rapidly cool the same. The lens will show a cross-shaped strain pattern when viewed through a polariscope. (See Fig. 2.)

Cooling is not alone critical to the formation of the cross-shaped strain pattern of Fig. 2 in the lens. For example, if air is directed against the heated lens through an orifice having a diameter of ¼" or larger, the cross-shaped strain pattern of Fig. 2 is not obtained.

Due to the difficulty of properly cooling the lens to obtain toughness, it is preferred not to employ air jets having orifices with diameters of the magnitude of ¼" or larger. If desired the diameter of the orifice can be greater than 1 mm., say 2 mm., but with the increase in the diameter of said orifice it becomes more difficult to effect a rapid cooling sufficient to form a strain pattern in the lens. This results from the fact that it is difficult to properly focus the air on the heated lens and mainain the proper air pressure to rapidly chill the lens. Generally a lens characterized by a uniform strain pattern is tougher than one which is not so characterized, but the invention extends to any spectacle lens wherein air or other gas is employed as the cooling medium.

EXAMPLE IX.

A spectacle lens, corrected for vision, made of conventional spectacle crown glass and having a thickness ranging between 1.0 mm. and 2.2 mm. at its thinnest point, is uniformly heated in a temperature controlled oven for three minutes at a temperature of 1150° F. After the heating period the heated lens is carefully removed from the oven and disposed in a heat exchange relationship with a pointed solid conductor, e.g., copper, iron, etc. The pointed metal conductor preferably does not contact the heated lens for it is found that the lens usually cracks when employing a metal having a high coefficient of heat conductivity unless a very small area contacts the heated lens, e.g., an area having a diameter of 0.05 to 0.5 mm. depending upon the coefficient of heat conductivity of the particular metal employed.

EXAMPLE X.

A lens, corrected for vision, or an unground lens blank is uniformly heated to soften the surfaces thereof, the time and degree of heating being such that lens or lens blank substantially maintains its original shape without sag or warp beyond allowable tolerances. The heated lens or lens blank is rapidly cooled through the medium of a solid pointed conductor which may or may not touch the heated lens or lens blank depending upon its coefficient of heat conductivity compared with the rate at which the heated lens would lose heat to its surroundings but for the rapid cooling means. The rapid cooling means is substantially less in area at the spot it contacts or otherwise establishes a heat transfer relationship than the total area of the heated lens. It is found that the heated lens will crack if the point of lens contact is too large in area. For example, a carbon point having a diameter of 1 mm. will not crack the lens upon contact therewith, while a copper point having the same area will usually crack the heated lens when it contacts the same.

EXAMPLE XI.

Optical glass is heated to approximately its softening point and is rapidly cooled through the medium of one or more solid conductors, preferably pointed and gradually increasing in cross-sectional area for approximately 1 inch from the pointed portion. The area of the point at spot of glass contact will vary with the coefficient of heat conductivity of the conducting material. The greater the coefficient of heat conductivity the smaller the area of the point which can safely contact the heated optical glass without cracking the same. Air or any other suitable gas may be employed to assist in the rapid cooling step. The rapid cooling step employs one or more pointed or tapering solid conducting rods or one or more pairs of solid conducting rods, either alone or in combination with air, preferably under pressure.

The above examples are only illustrative of the invention. It is to be understood that the times and temperatures set out in the graph are not critical in all aspects but are a guide to indicate operable times and temperatures, particularly in the 1100°—1200° F. temperature range at which no sag or warp is produced in lenses having a thickness in the neighbourhood of 2 mm. at their thinnest points. It was found convenient to heat a drilled lens having a minimum thickness of 1.7—2 mm. and corrected for vision at temperature of 1125° F. for a period of five minutes before applying supporting pressure to the lens during the cooling period. Heating at this temperature and for this time was chosen to allow for a certain amount of error without spoiling the lens. Heating for four minutes at 1125° F. will usually not give as tough a lens as heating for five minutes. Heating for six minutes at 1125° F. will cause the lens to sag or be so close to the sagging point that a slight increase in time of heating would ruin the lens. Of course, slight sagging can be tolerated.

In treating colored lenses the temperature of heating is generally lower because of the difference in the composition of the lenses. The colored lenses absorb heat much more readily than colorless lenses and, consequently, the temperature or time of heating must be decreased. The specific temperature and time of heating depends upon the specific composition of the colored lens being treated.

Good results can be obtained if the lenses which have been corrected for vision and are being treated according to the present method for toughening optical glass, are made of spectacle crown glass free from bubbles or flaws which are visible to the unaided eye. The surfaces of the lens should be completely polished and free from defects which affect optical performance. The lenses should be cleaned before treatment in order to insure best results. Satisfactory results can be obtained with optical glass of any quality.

Generally the temperature and time for which any one lens is heated prior to the step of conducting heat away from the heated lens at a rate which is different from the rate at which the heated lens would normally cool so as to form a normally invisible strain pattern in the said lens, depends upon the proportions, composition and character of the particular lens being treated. Ordinarily when dealing with a lens of spectacle crown glass, having a thickness in the range of 1.7—2.2 mm. at its thinnest point, the temperatures and times given on the chart of Fig. 1 are productive of good results particularly within the 1100°—1200° F. range. Other temperatures and times are suitable but it is preferred to work in the 1100°—1200° F. range for maximum productive efficiency with a minimum of error.

It is possible to deviate from the times and temperatures set forth in the chart of Fig. 1 and still obtain good results. At slightly higher temperatures, time remaining constant, it is possible to obtain a tougher final product. Generally the lens heated at the higher temperature

and for the longer time is tougher. However, the lens should not be heated at too high a temperature and for too long a time so that the toughened lens is warped or sags. Slight sagging can be tolerated without ruining the lens.

As a lower limit for heating the glass it should be heated for such a time at any temperature so that a strain pattern is obtained when heat is conducted away from one portion thereof faster than it is conducted away from another portion.

When treating lens of greater thickness, it is preferred to heat the lens for a longer time in order to soften the surfaces thereof. For example, a lens of 3 mm. thickness at its thinnest point can be heated for about 5 minutes at 1150° F. with good results.

Greater care must be exercised when treating a lens having a thickness of 0.5 mm. to 1 mm. at its thinnest point for fear of overheating the lens. When treating such thin lenses, it is preferred to work at lower temperatures for a longer time of heating to minimize error.

It is impossible to specifically set out all the operating conditions as to temperatures and times for all various sized lenses of varying thicknesses. It is important to remember that the lens should be heated to soften the surfaces thereof at such a temperature and for such a period of time that the lens retains or substantially retains its original shape upon cooling. It is not intended that the word "soften" as used in the description of the invention, include heating of optical glass to so soften the same that it will not substantially retain its original shape upon cooling within allowable tolerances depending upon the exact use of the optical glass.

In carrying out the preferred form of the invention wherein the lens is under pressure while cooling, an ordinary spectacle lens is selected which has been corrected for vision, and having a thickness of 2 mm. at its thinnest point. The oven is preferably heated up to 1200° F. to thoroughly heat the walls thereof. The rheostat or even switch is then regulated so that the oven temperature is 1150° F. as indicated by the pyrometer.

The lens being treated is cleaned and placed in the lens stand, convex surface down. If the lens is drilled, it preferably should be placed on the stand so that the holes in the lens will not be over any one of the three arms on the lens stand. If the lens is bifocal, the segment should not touch any one of the three arms on the stand.

While the oven is heating it is preferred to place the lens to be treated on the top thereof so as to remove the chill therefrom before inserting the lens and stand into the hot oven.

Now that the oven is at 1150° F. the lens stand and lens are inserted into the oven and the door quickly closed so as to maintain the temperature substantially at 1150° F. The temperature may vary somewhat from 1150° F. without affecting results but it is preferred to maintain this temperature.

The lens is heated for three minutes and then withdrawn and placed between the carbon points 28 and 30 by elevating the rod 27 and then carefully bringing it in contact with heated lens on a central point thereof and lowering the rod 27 and heated lens until said lens rest upon the point 30. The lens stand encircles the lower rod 29 and is removed therefrom.

The heated lens is supported between the points 28 and 30 and is allowed to cool naturally under supporting pressure. After the lens cools, it shows a well-defined cross-shaped strain pattern therein which is visible through a polariscope.

While the said lens cools, supported between points 28 and 30, another lens can be heated in the oven. The operation can be controlled so that a plurality of lenses can be serially treated, each of said lens being characterized by an identical or substantially identical normally invisible strain pattern.

The apparatus employed in describing the invention is merely illustrative. Any suitable means can be employed to heat the lenses at substantially a constant temperature for a certain length of time depending upon the composition of the optical glass being treated. Other suitable means for applying pressure to a heated lens wherein a different heat transfer relationship is established at the point of pressure application, will be obvious to those skilled in this art. For example, a springed clamp provided with carbon contact points would be suitable for exerting pressure on oppositely disposed points on the surface of the heated lens. Pressure can be applied at a plurality of points on the same side of a heated lens and it is not necessary that the pressure be maintained until the lens has full cooled to obtain good results.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, as communicated to me from abroad, I declare that what I claim is:—

1. Method of toughening a lens or like article of glass by heating the article to near softening point and rapidly cooling it, characterized by effecting said cooling

through the medium of a solid conductor or a jet of gaseous cooling medium applied at the centre point of symmetry of a desired strain pattern in the glass.

2. A method according to claim 1 in which cooling is effected by rapidly conducting heat away from the heated glass through the medium of one or more solid conducting points.

3. A method according to claim 2 wherein the heated lens is supported between two oppositely disposed conducting points.

4. A method according to any of claims 1—3 wherein the heated lens is suspended horizontally in air while being cooled.

5. A method according to claim 2, 3 or 4, comprising substantially centrally supporting the heated lens between the two oppositely disposed conducting points and allowing the lens to cool in its supported position, whereby a normally invisible cross-shaped strain pattern is formed in the lens.

6. A method according to claim 5 in which the lens is heated to between 1125°—1150° F. for a time ranging from five to three minutes.

7. A method according to any of claims 2—6 in which the heated lens is supported and cooled between two oppositely disposed rounded carbon points having a diameter of approximately 1 mm.

8. Method according to claim 1 comprising applying a rapid cooling pressure jet of restricted cross-sectional area to said heated lens.

9. A method according to claim 7 in which air under pressure is blown against the heated lens on a point substantially at the centre thereof.

10. A toughened lens or like glass article corrected for vision and characterized by a strain pattern visible through a polariscope and produced by any of the methods claimed in claims 1—9.

11. A toughened drilled spectacle lens corrected for vision and adapted for use in rimless spectacles, according to claim 10.

12. A lens according to claim 10 or 11 having a cross-shaped strain pattern.

13. A toughened spectacle lens according to claim 12 having a thickness of approximately 2 mm. at its thinnest point, and its cross-shaped strain pattern having its center point substantially in the center of the lens.

14. Apparatus for cooling a heated lens or like glass object in tempering characterized by a pointed conductor of heat, or a fine jet for delivery of gaseous cooling medium under pressure, applicable to the centre point of symmetry of the desired strain pattern in the lens while it is supported in air.

15. Apparatus according to claim 14 comprising two pointed conducting rods in substantial axial alignment, one of which is movable and a support for each of said rods, said rods being arranged to support the lens in horizontal position.

16. Apparatus according to claim 15 comprising detent means adapted to limit the movement of the movable rod toward the other rod.

17. Apparatus according to claim 14, 15 or 16 comprising a supporting base, an upright member carried by said base, a vertically movable arm pivotally supported on said upright member, a pointed carbon rod carried by said arm, a second pointed carbon rod carried by said base and in substantial axial alignment with said first-mentioned rod, a detent associated with said arm and adapted to stop the downward movement of said first-mentioned carbon rod short of said second carbon rod, and means to urge said first carbon rod toward said second carbon rod.

18. Apparatus according to claim 17 in which each carbon rod has a rounded point with a diameter of approximately 1 mm. at one end thereof.

Dated this 5th day of May, 1943.
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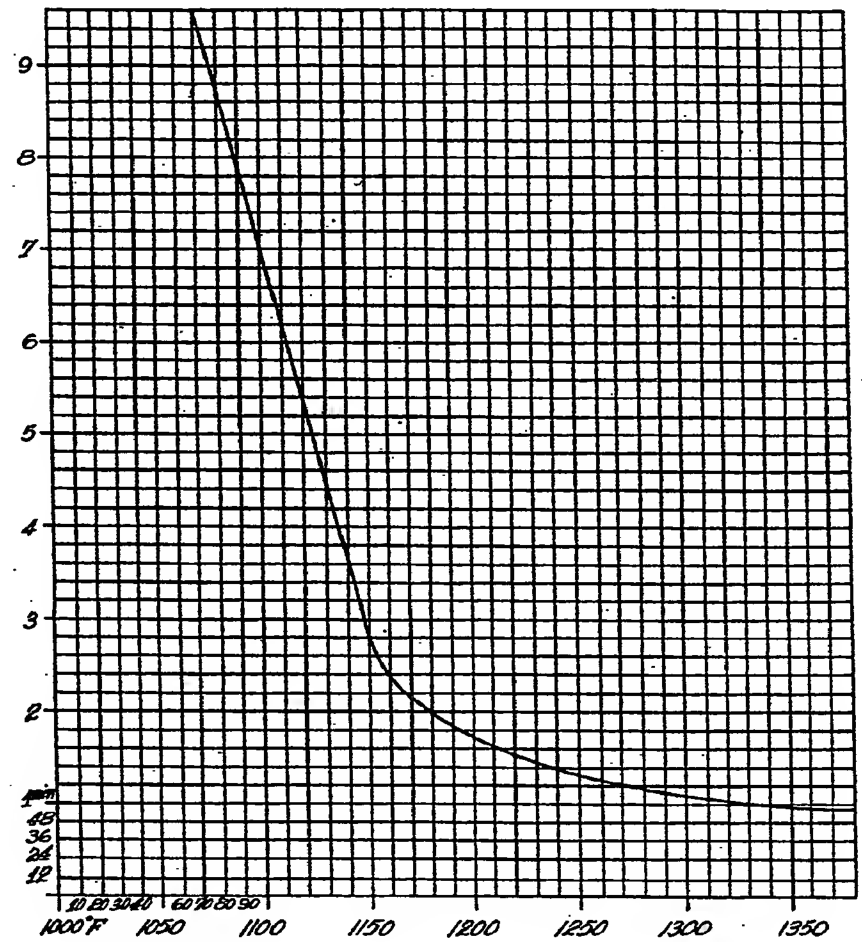
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Fig 1

SHEET 1

SHEET 2

Fig.2

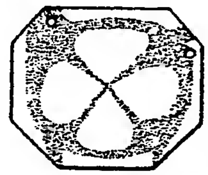


Fig.3

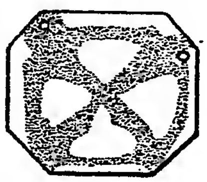


Fig.4

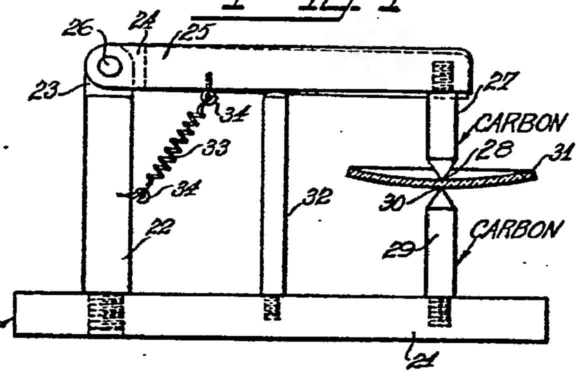


Fig.5

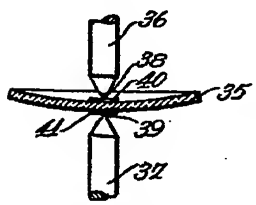
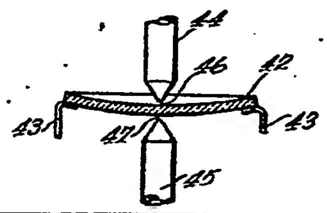


Fig.6



SHEET 3

Fig.7

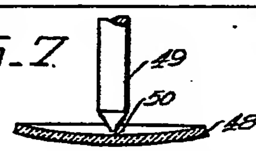


Fig.8

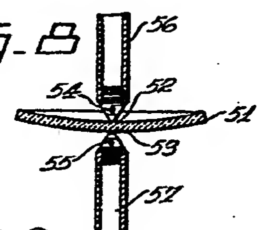
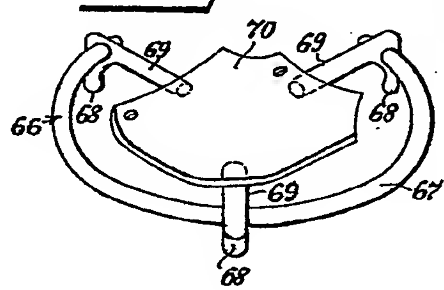


Fig.9



563,800 COMPLETE SPECIFICATION

3 SHEETS
SHEET 1

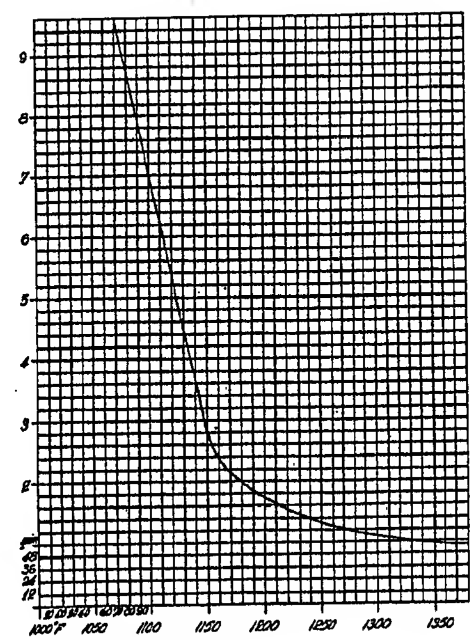


Fig.1

SHEET 2

Fig.2

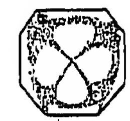


Fig.3

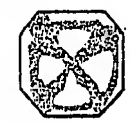


Fig.4

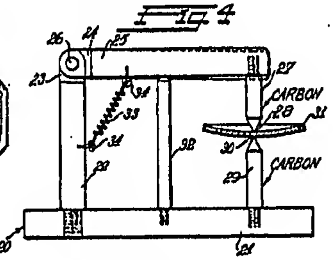


Fig.5

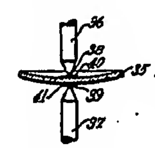
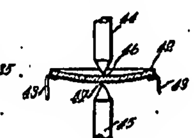


Fig.6



SHEET 3

Fig.7

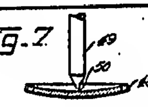


Fig.8

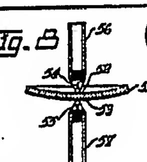
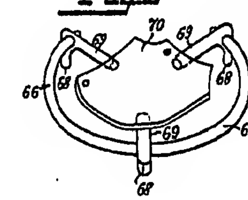


Fig.9



[This Drawing is a reproduction of the Original on a reduced scale.]

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